

Problem

Phenylketonuria (PKU)

Genetic disorder preventing metabolism of amino acid phenylalanine (Phe)

- High Phe levels leads to intellectual disability
- No cure - patient must adhere to strict lifelong diet

Problem: PKU patients do not have a method to quickly check their Phe levels



Send blood to lab

Results inform diet

Objectives

Leverage **paper microfluidics** to create a simple, at-home diagnostic device to measure phenylalanine in blood

Current Design

Optimize pH conditions in device and characterize performance

Performance Goals

Sensitivity: $< 1 \frac{\text{mg}}{\text{dL}}$ Phe **Error:** $< 5\%$

Paper Microfluidics

Use low-cost porous materials as a platform for health diagnostic tests



Glucose and Protein Test [1]

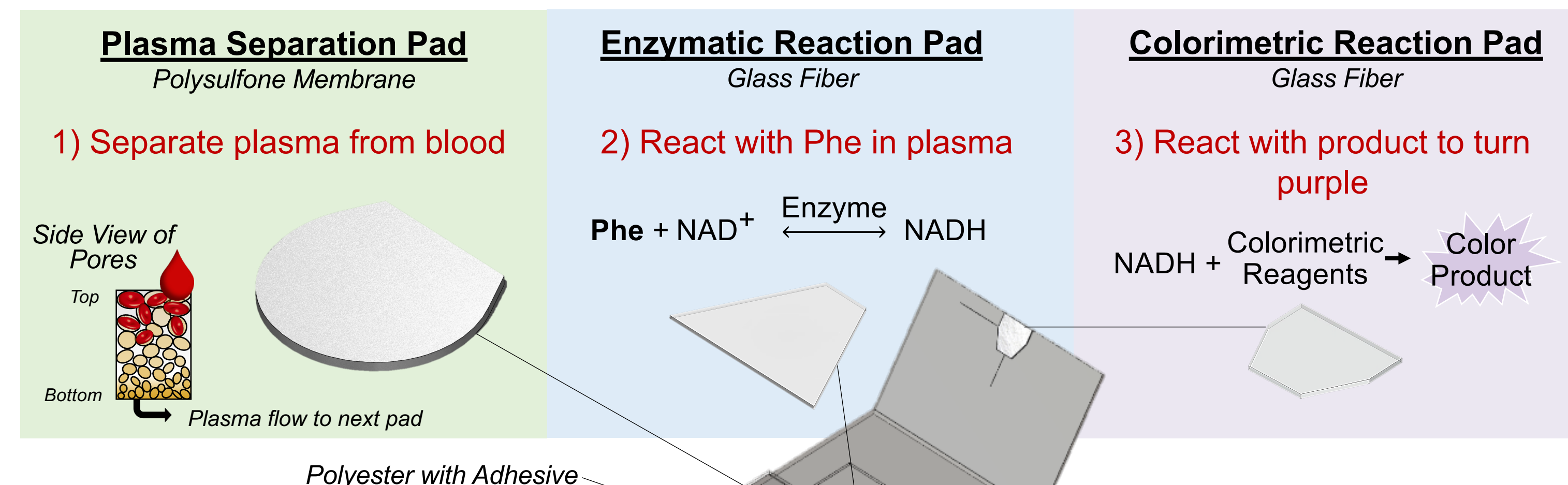


Pregnancy Test [2]

- No external pumps needed - fluid moves by capillary action
- Complex laboratory tests can be translated to a small, portable and easy-to-use format

Device Design

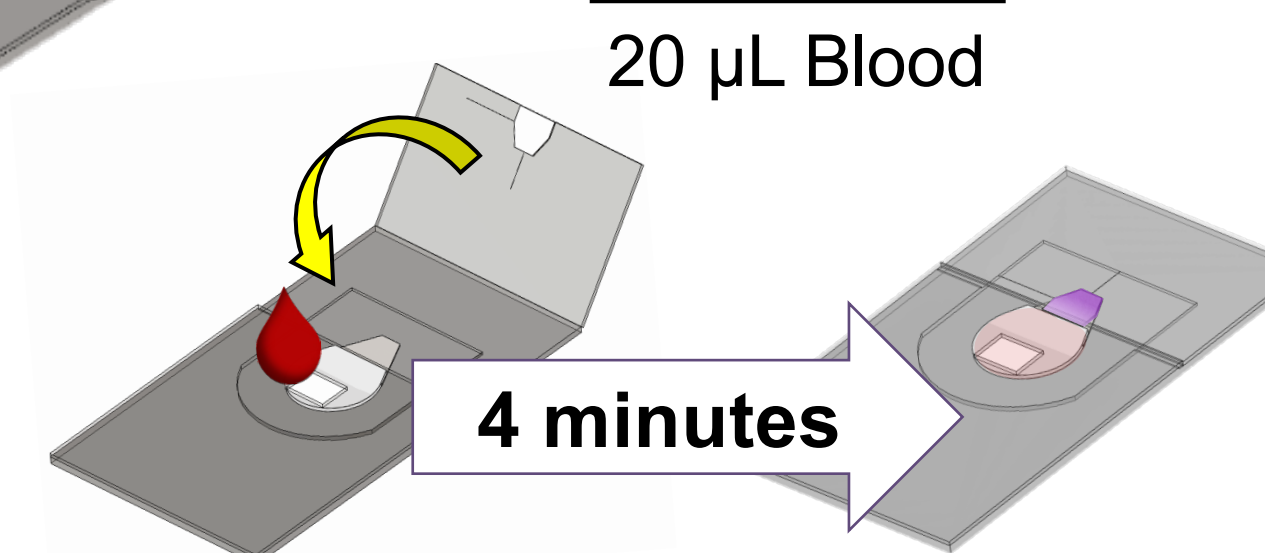
Three Main Device Components



Fabrication Process

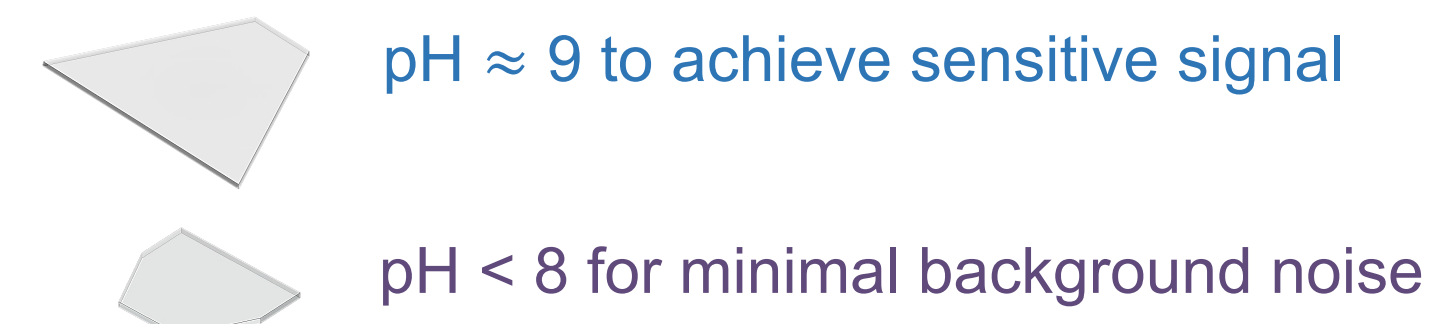
- 2-D AutoCAD design
- Cut materials with CO₂ laser
- Dry reagents in porous materials
- Adhere porous pads to polyester support

Device Use

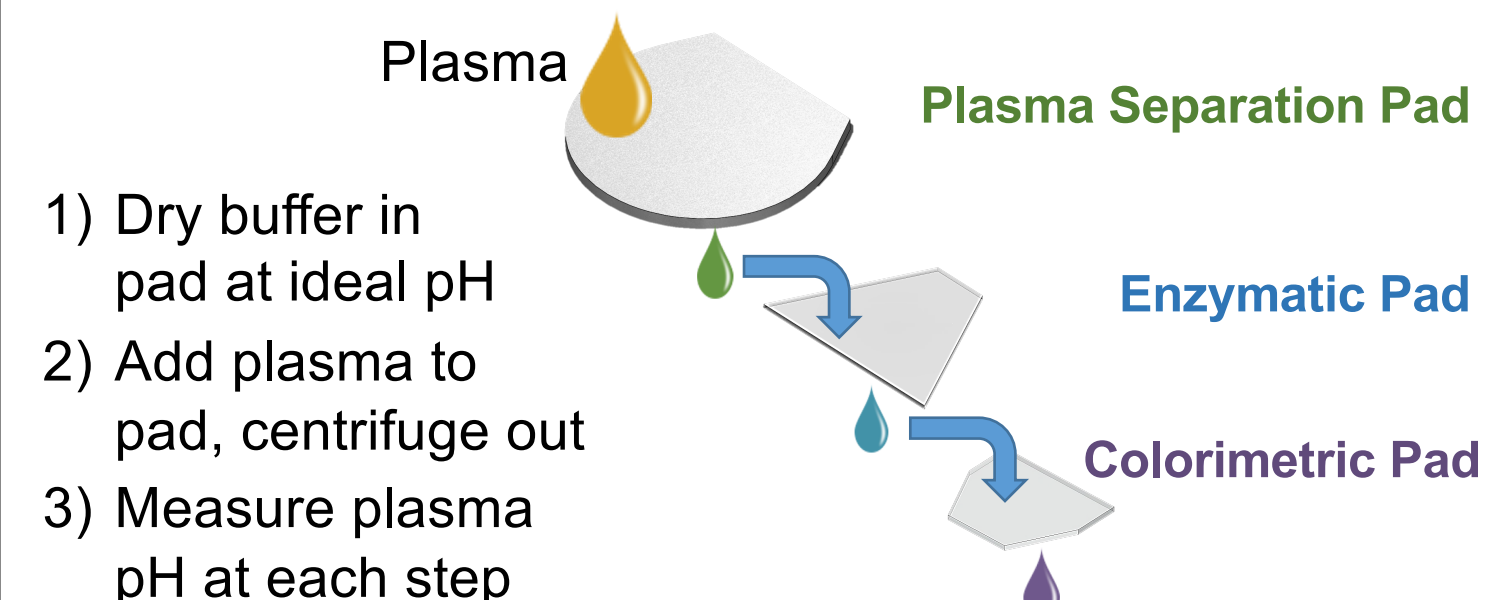


Test Optimization

Challenge: each chemical reaction requires a different ideal pH condition



Method to measure pH changes in device



Solution

- Use one buffer with large buffering range: pH 6.2 - 9.4
- Dry reagents in pads at each ideal pH

Required pH Achieved in Device with Optimized Dried Buffer Conditions

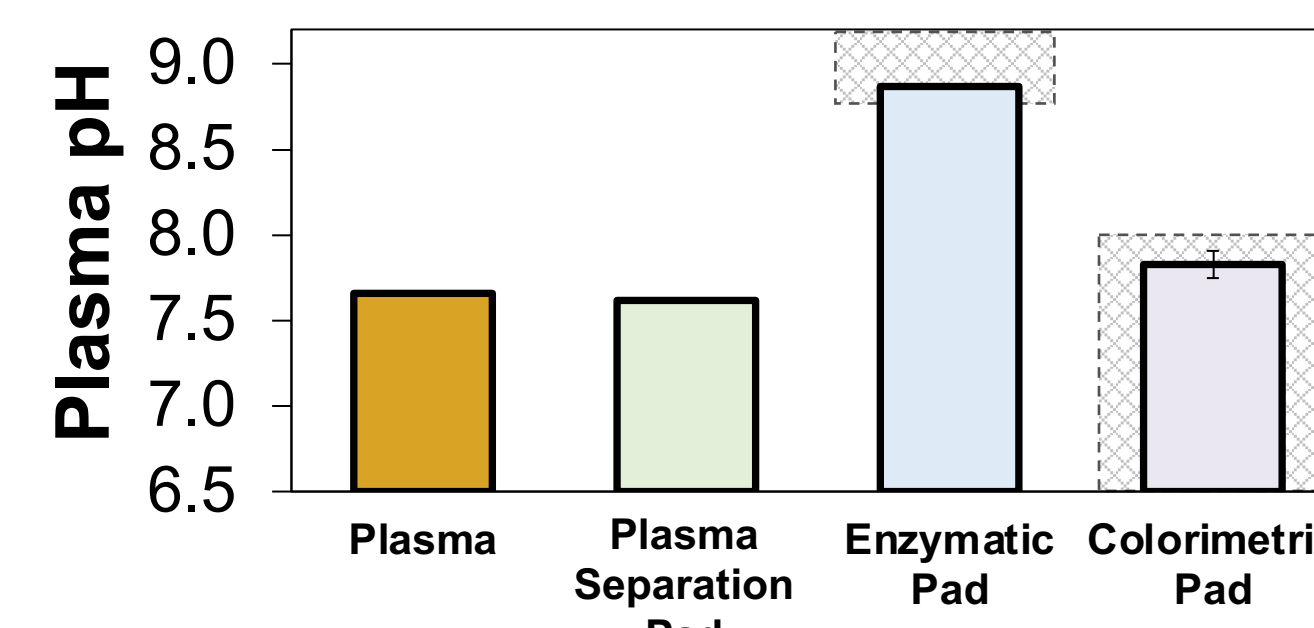


Figure 1: Measured pH of human plasma in device. Grey hatched areas are ideal pH zones for that pad. N = 4, Error Bars: 95% CI

Conclusion

Device performance met goals after buffer pH optimization

- Sensitive to Phe 0.8 $\frac{\text{mg}}{\text{dL}}$
- Low error (coefficient of variation) 3%
- Device design can be used to develop other rapid diagnostic tests

Device Phe Concentration Curve

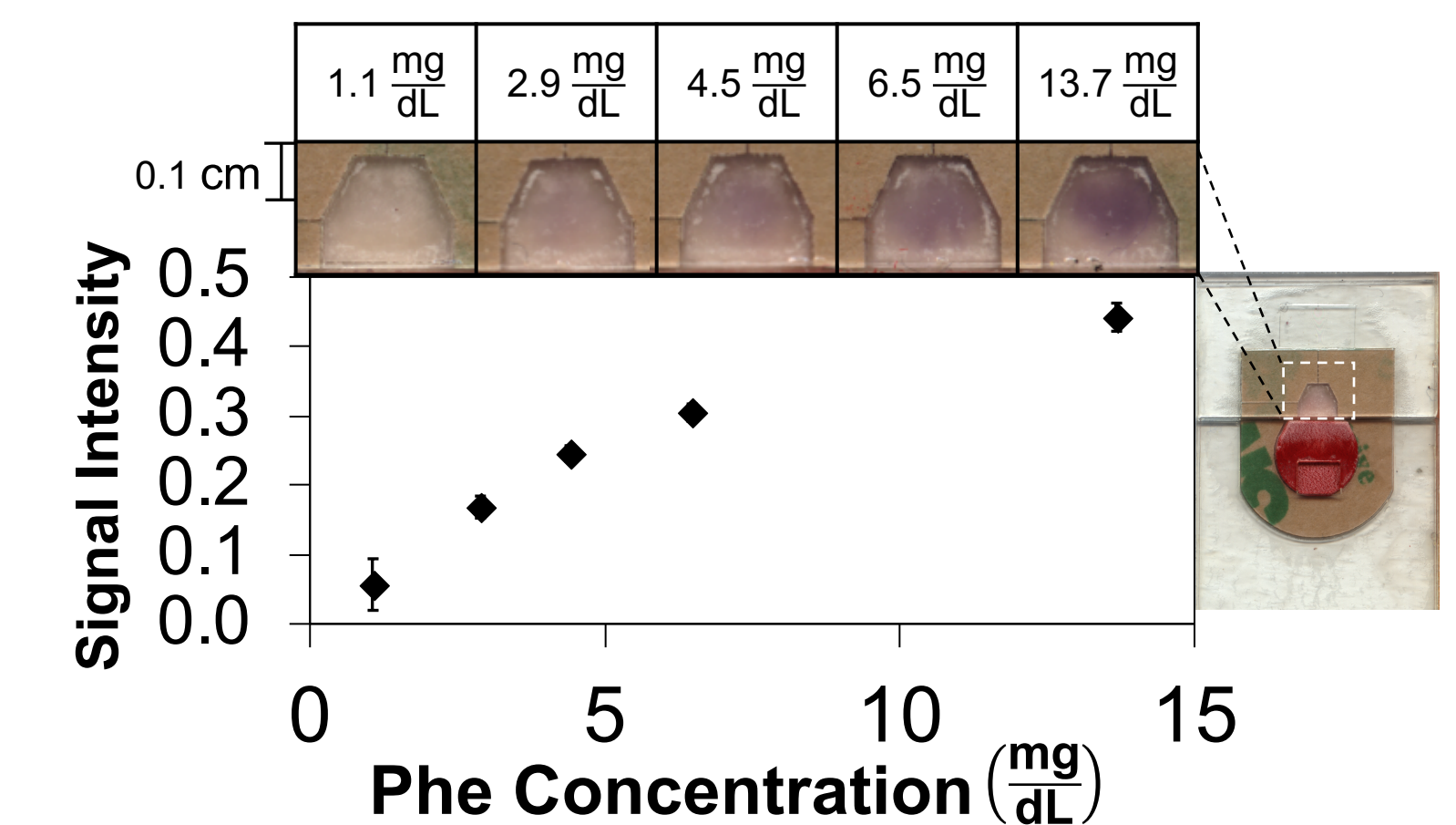


Figure 2: Phe concentration curve and representative images of device signal. Tested with Phe spiked human whole blood. N = 5, Error Bars: 95% CI

Next Steps

- Investigate long term storage of dried reagents within device
- Compare device sensitivity to laboratory Phe tests using PKU patient blood

References

- [1] G. Whitesides et al. "Paper-Based Analytical Device for Electrochemical Flow Injection Analysis of Glucose in Urine" 2012
- [2] Clearblue. Image of commercial pregnancy test. 2019.

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Contact:

wentlanl@oregonstate.edu

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